Q & A

Matthew Cobb

Matthew Cobb is Senior Lecturer in Animal Behaviour at the University of Manchester. He earned his PhD in Psychology and Genetics from the University of Sheffield in 1984, and spent most of his career in France. He specialises in insect behaviour, with a focus on chemical communication and the olfactory responses of Drosophila *larvae. He recently co-edited* Insect Taste *and has translated a number of books on the history and philosophy of science. As well as writing for publications such as the* Times Literary Supplement*, the* Los Angeles Times *and* Permanent Revolution*, his book on the 17th century discovery of egg and sperm appeared in 2006 (*The Egg & Sperm Race*, published in the US as* Generation*). His history of the French Resistance in the Second World War will appear in June 2009 (*The Resistance: The French Fight Against the Nazis*).*

What got you into the study of behaviour? It was touch and go, to be honest. I was torn between studying politics and working in forestry. If things had taken a different track I'd be working in a pine forest somewhere in the wilds of Scotland, or perhaps be a journalist. My decision to study behaviour came in a flash one day when I read about a degree in psychology — something clicked inside me and I knew that was what I wanted to do. Two years later, in 1976, I made another snap decision to study *Drosophila* after reading a short paragraph in *New Scientist* about the discovery of the *dunce* learning-deficient mutant in Seymour Benzer's lab.

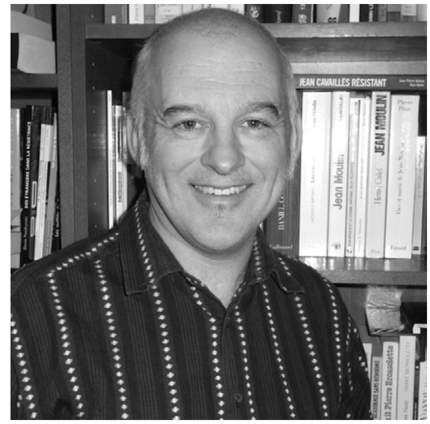
What's so interesting about insects? Sir Martin Rees, the British Astronomer Royal, put his finger on it when he said: "An insect is more complex than a star." We know when the Sun will explode, but we can't predict exactly what an insect will do next. The combination of lawfulness and random behaviour makes biological systems fascinating. Insects are apparently at the mechanical end of the spectrum of life, and yet they show amazing variability in their behaviour. Explaining that is a great challenge. Plus, of course, you can fool about with them in all sorts of ways that are impossible, or strictly controlled, in vertebrates.

What's your greatest weakness? From a strict research-focused, career path point of view, I'm interested in too many things. I study the sense of smell in *Drosophila* and *Tribolium*, but my office is full of model stegosaurs, I have published on handedness in dogs and am working on an article on pine-cone eating in squirrels, I write books about history and I teach a field course in behaviour and ecology. And throughout my time in France I was heavily involved in far-left politics (not unusual in the country that gave us the rebellion of May 1968). If I'd just done the fly stuff, I would probably have been a lot more productive — but certainly far less fulfilled.

What has been your biggest mistake? Not thinking through a casual observation I made during my PhD. I noticed that if I kept males of some *Drosophila* species together, they showed intense male–male courtship. I thought this was weird, but didn't bother to wonder why. It turns out that in these species the pheromones of males and females are identical, so if you keep males together they get very excited. I could — and should — have predicted the chemical basis of what I observed.

What's the best thing about science? Making sense of experiments and designing the next one. It's finding out stuff that's really exciting, not simply knowing facts. That's what I enjoy about teaching on a field course, in which each student does their own research project for about 10 days. We have to work out how we can measure, say, fish responses to alarm pheromones, or test Hamilton's 'selfish herd' hypothesis, or explain the distribution of wood ant nests. Such projects test your ingenuity, are intensely stimulating, and give the students a rich experience.

What's the worst thing about science? The lack of black scientists. This does not only affect science — UK universities as a whole have a very low number of students from the Afro-Caribbean community. Even in the U.S., where there are many leading Afro-American academics,



few black students make it into the world of scientific research. Although the election of President Obama may signal a change, at the moment members of the black communities in all Western countries tend to do less well in school, and therefore fewer of them end up in the higher levels. This situation not only reflects and reinforces racial discrimination, it also means that we are depriving ourselves of potentially important talent.

What's the best part of your job? Apart from the privilege of being paid to think and do experiments, I really enjoy teaching — both my own research, stuff I am just interested in, such as the Ediacaran biota, or which I think is really important, such as teaching the evidence for evolution to First Year students. I also produce a weekly electronic zoology newsletter, which features everything from ludicrous YouTube videos to the latest research from *Current Biology* and the specialist journals — send me an e-mail if you want to be on the list.

Why should scientists care about history? The exciting thing about science is its continual looking to the future, to the next experiment, to the discovery that will change how we look at the world. But that obsession has its negative aspects — it means we are vulnerable to being beguiled by fashion, focusing on short-term impact, and generally failing to see the forest for the trees. On the other hand, if you think too much about the historical scale, even in terms of decades, it's somewhat de-motivating — very little of what most of us do will leave any direct trace. Finding the balance between sensing the historical depth of our understanding of the natural world and thriving from the excitement of experimentation is my key to being a happy scientist. But for all but the most brilliant scientists, our real influence will come through that most undervalued part of our work – teaching.

What's your next historical work on? I'm thinking about the power of metaphor in science and the way it frames and limits how we think about the natural world. I've already written about 17th and 18th century approaches to heredity, and the history of the genetics of behaviour in the 1950s. In both cases, scientific progress was limited by the metaphors people used. The early modern view that animals were machines could not cope with hereditary phenomena that combined both blending inheritance and particulate inheritance, and so people simply ignored the problem. 250 years later, the ethologists of the 1950s and 1960s seem to have not picked up on the analogies with cybernetics — feedback loops and so on — that were being used with such effect by the molecular biologists. I want to expand this to a more general analysis of the role of metaphor in science.

What's the next Big Thing? In broad terms, the molecular tools that have been developed in a handful of model systems will be applied to a wide range of really interesting organisms that have a known ecology and natural history. More specifically, I think we may start to look at animal behaviour in a novel way. With the genomes of the 12 *Drosophila* species, *Nature* published a think-piece by Leslie Vosshall. She concluded with a suggestion that *Drosophila* could be used to study the neurobiological bases of emotions such as empathy and hatred – "The only a priori limitation to studying any of these traits is the belief that flies can show such emotions and the design of a plausible behavioural paradigm to measure them." At the time, I thought this was hubristic. On reflection, I think she may be right, and I am currently pursuing some of these ideas. In 10 years time, I suspect we will have made some surprising progress using insects to study traits that were previously thought to be restricted to higher animals.

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Quick guide

Ocelli

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What are ocelli? Ocelli (singular *ocellus*) is Latin and means little eye. One to three ocelli can be found in many insects, located at different positions on their heads. Ocelli have evolved as a second visual system, in addition to the compound eyes that insects are famous for.

Which insects have ocelli? Most flying insects have ocelli, while those that never get airborne usually don't have them. There are of course exceptions, but there is a high probability that, if you are a flying insect, you will have ocelli. For example, locusts, dragonflies, cockroaches and most species of flies are all equipped with ocelli. Many studies on ocellar function have been done on these species.

What do we know about how ocelli work? That is a good question. It is only recently that progress has been made towards an answer. Let's start with the way that ocelli are constructed. Ocelli are similar to our own eyes in that they use a single lens to collect light and project it onto a layer of light-sensitive cells, called photoreceptors. As frequently done with our eyes, you can compare an ocellus to a camera — a very bad one, though. By modifying the curvature of the lens, our eyes produce a crisp image more or less independent of the distance from the objects we are looking at. This is called accommodation and is similar to shifting the lens of a camera to focus an object precisely onto a CCD chip or film. The lens of an ocellus, however, cannot accommodate or be moved back and forth. Even worse, the ocellus lens is positioned so that it always under-focuses. As a result, the image at the photoreceptor layer shows hardly any image details. This is similar to what you get if the autofocus of your camera has failed to adjust quickly enough when taking a snapshot, and all you can see on the photograph are some bright and dark blurs.

So what are ocelli good for? Sorry — I didn't quite answer your question on the function of the ocelli, did I? They are obviously not made to provide any image details about the visual surroundings. But, like a photometer, they provide information about light levels. Imagine an insect buzzing around. It is usually much darker in the lower parts of its field of vision than in the upper parts, even under cloudy conditions. We know from studies in flies that there are three ocelli (Figure 1) to sample light levels at different but slightly overlapping patches in the upper visual hemisphere. The left and right lateral ocelli integrate light from extended areas centred about 45 degrees above the horizon in the left and right part of the lateral field of vision, respectively. The medial ocellus monitors the dorso-frontal part of the surroundings.

If the fly is caught by a gust of wind and is rolled to the left, the visual field of the left ocellus is suddenly exposed to the darker ground while the right ocellus, now seeing more of the sky, receives much more light. The neural machinery along the ocellar pathway analyses the change in illumination between the left and right ocellus, which tells the fly that it has been rolling to the left. Of course, this works also for roll movements to the right and, if the medial ocellus with its frontal visual field is included, the ocellar system can also figure out whether the fly encounters a nose-up or nose-down pitch movement. Altogether, the ocellar system informs the fly about changes in attitude, or in other words, body rotations in the horizontal plane.

But can't flies just use their compound eyes to work out orientation in space? That's a very good point. Actually, flies do use their compound eyes as well to work out what their orientation is or how they are moving in space. But there are a couple of reasons why compound eyes alone are not enough to provide information about orientation and self-motion. For one, the neural pathways receiving visual input from the compound eyes consist of a greater number of consecutive processing stages. Each stage is set up by specific types of nerve cells to process the incoming